Elements of Architectural Structures: Form, Behavior, and Design

ARCH 614

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Spring 2013

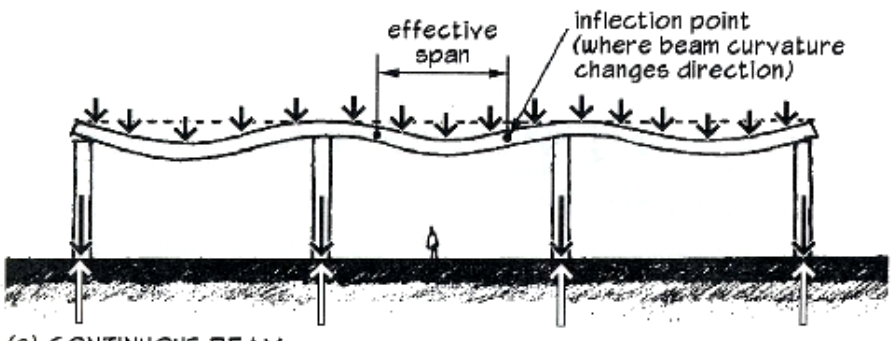
lecture ten

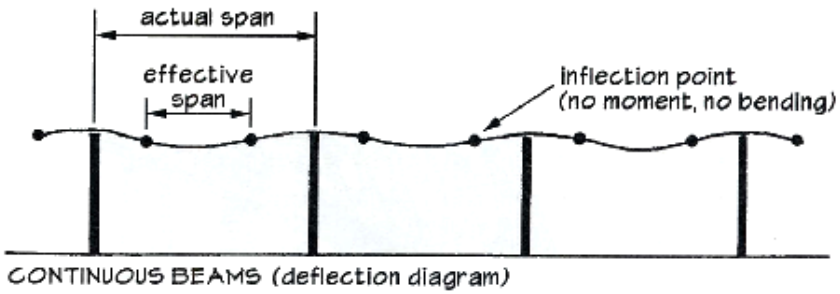
other beams & pinned frames

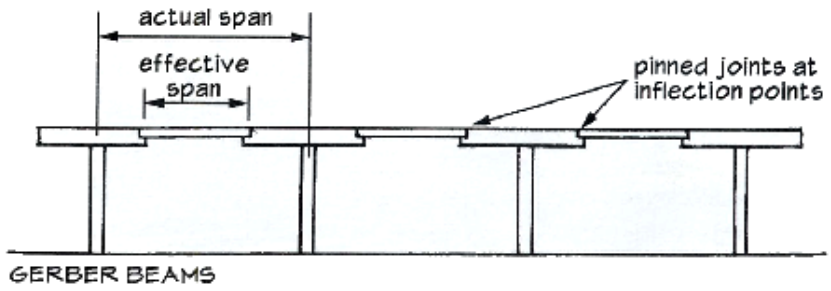
Continental train platform, Grimshaw 1993

Continuous Beams

- *statically indeterminate*
- *reduced moments than simple beam*

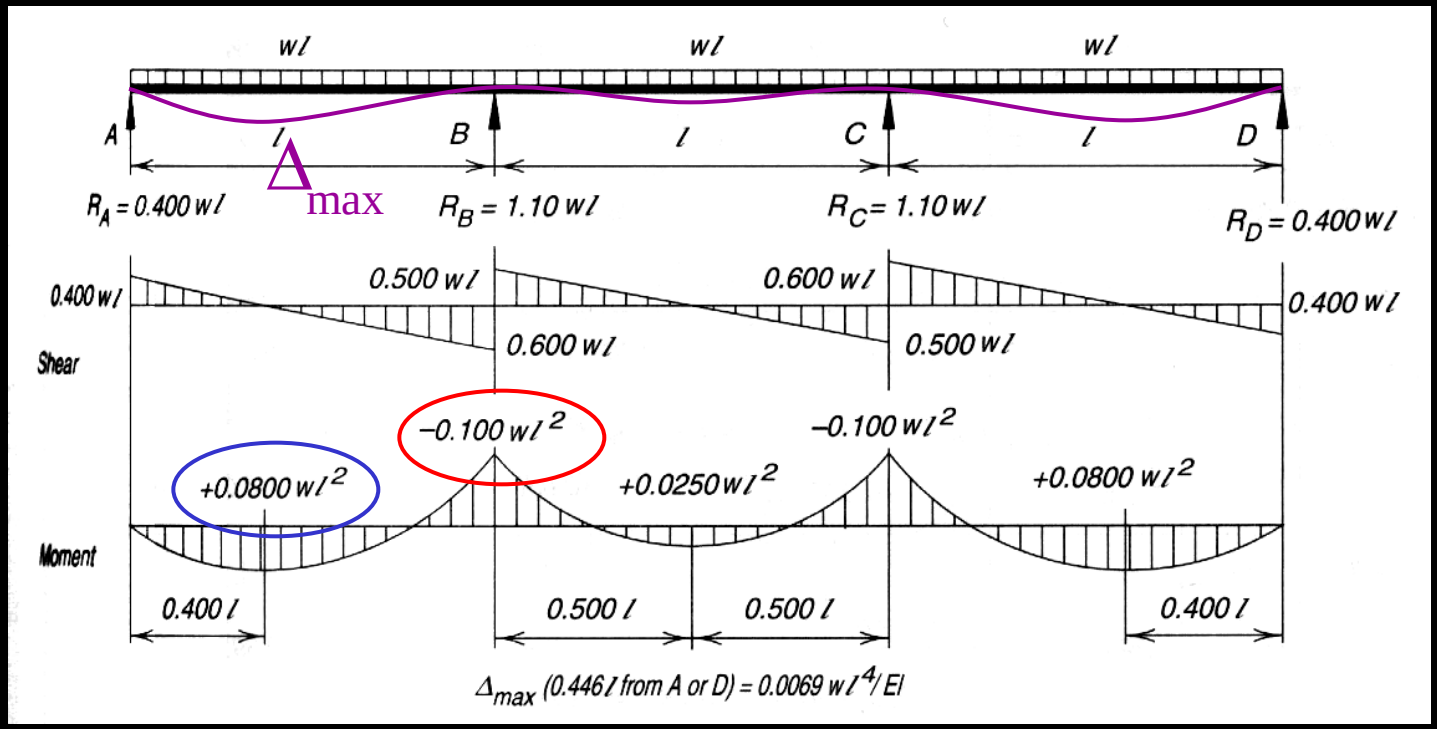






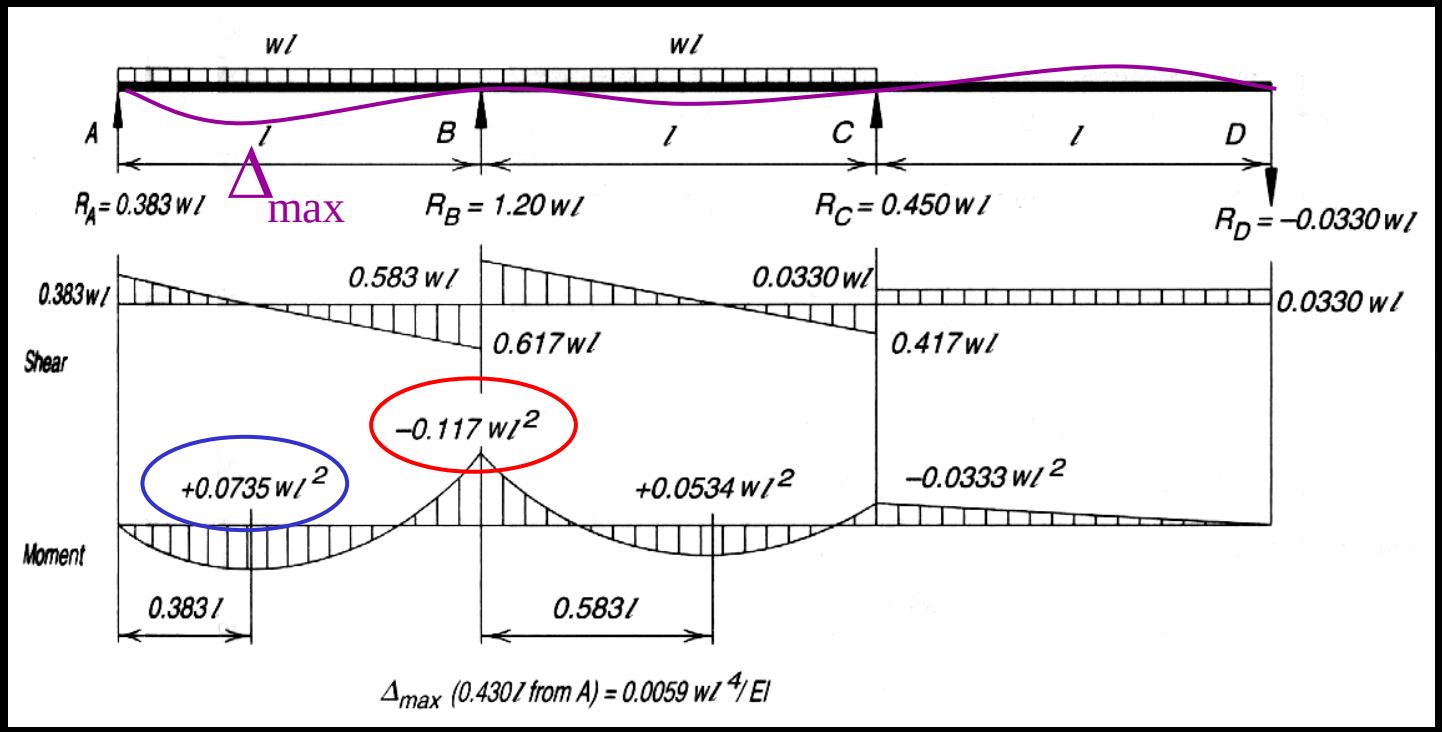
Continuous Beams

- *loading pattern affects*
  - *– moments & deflection*



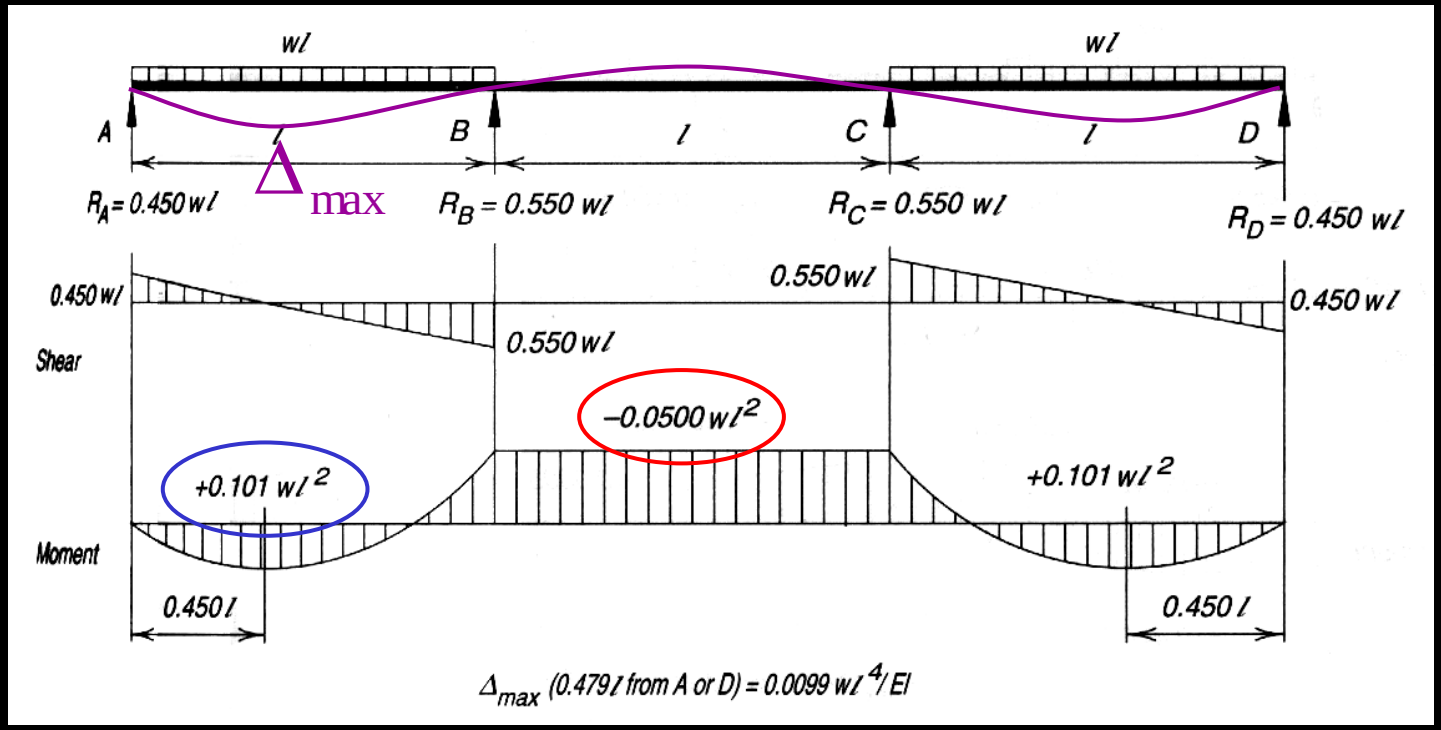
Continuous Beams

- *unload end span*



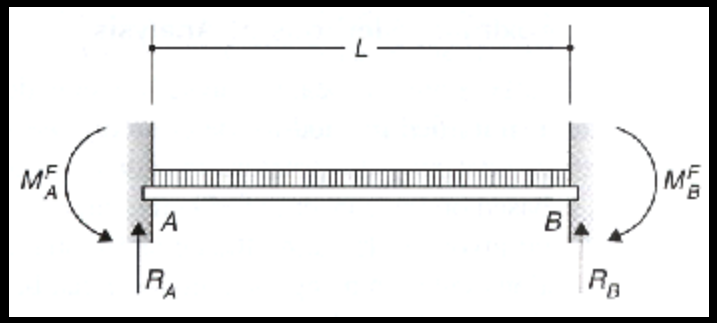
Continuous Beams

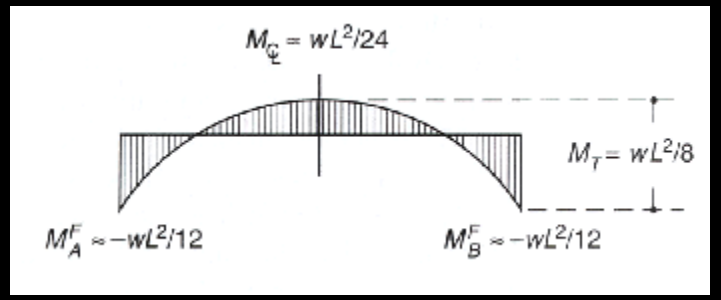
- *unload middle span*



Moment Redistribution

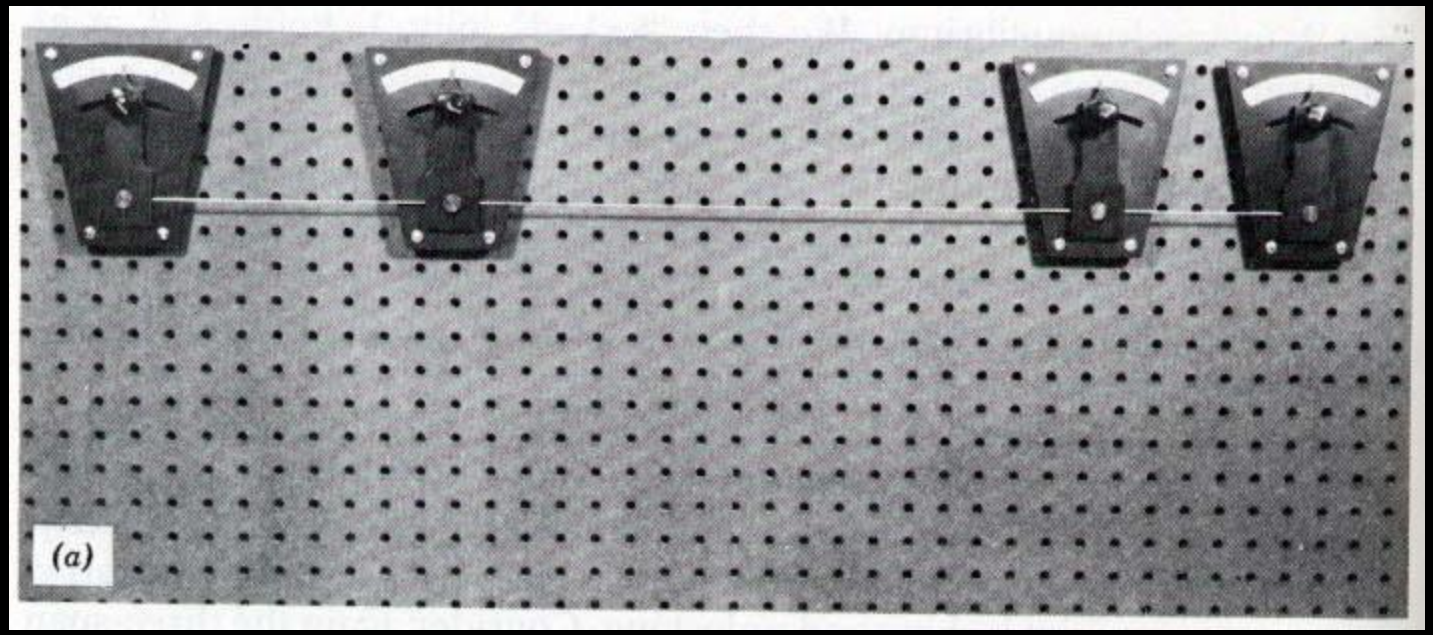
- *continuous slabs & beams with uniform loading*
  - *joints similar to fixed ends, but can rotate*
- *change in moment to center =* $\frac{wL^2}{8}$
  - M_{max} *for simply supported beam*





Moment Distribution (a)

- *no load*



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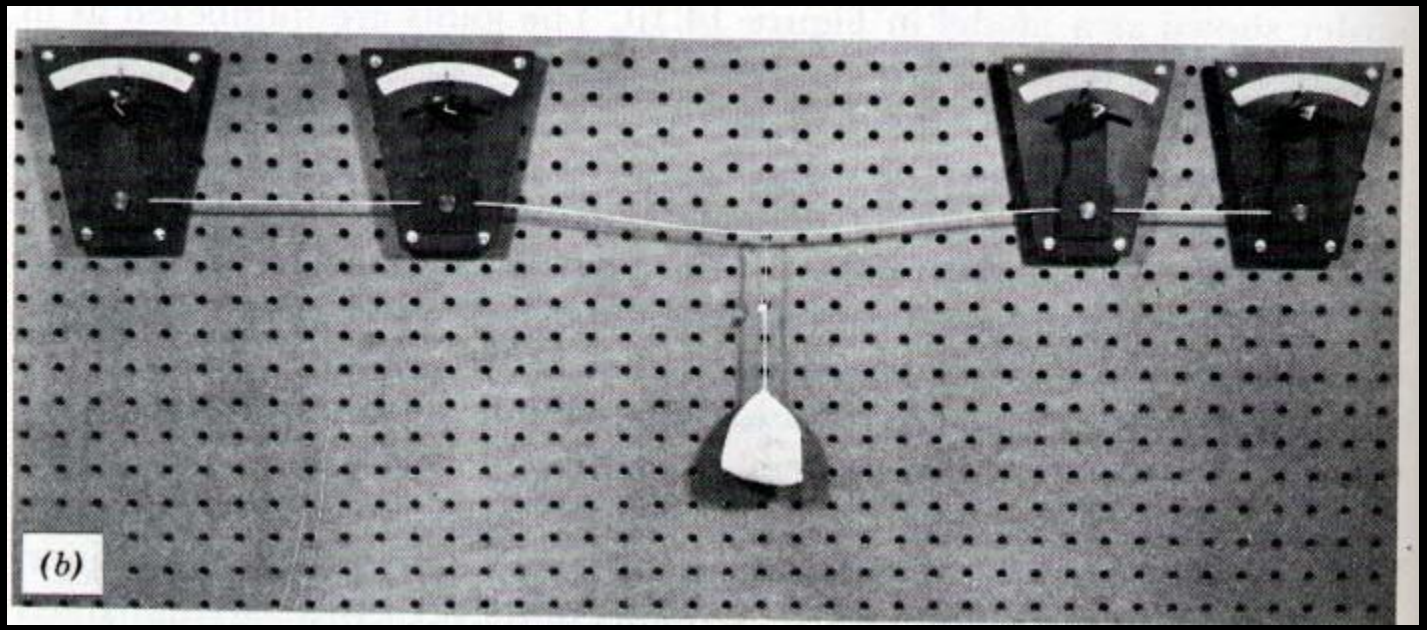
Moment Distribution (b)

- *add load*



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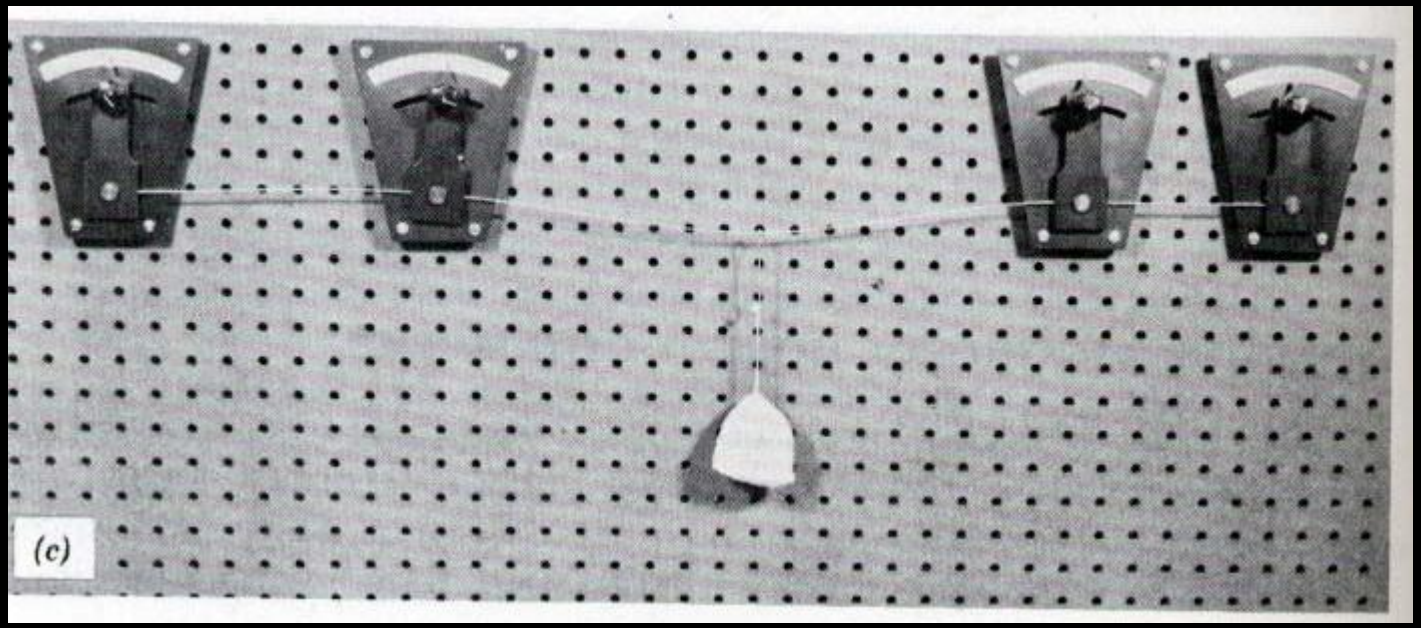
Moment Distribution Method (c)

- *release joint 2*



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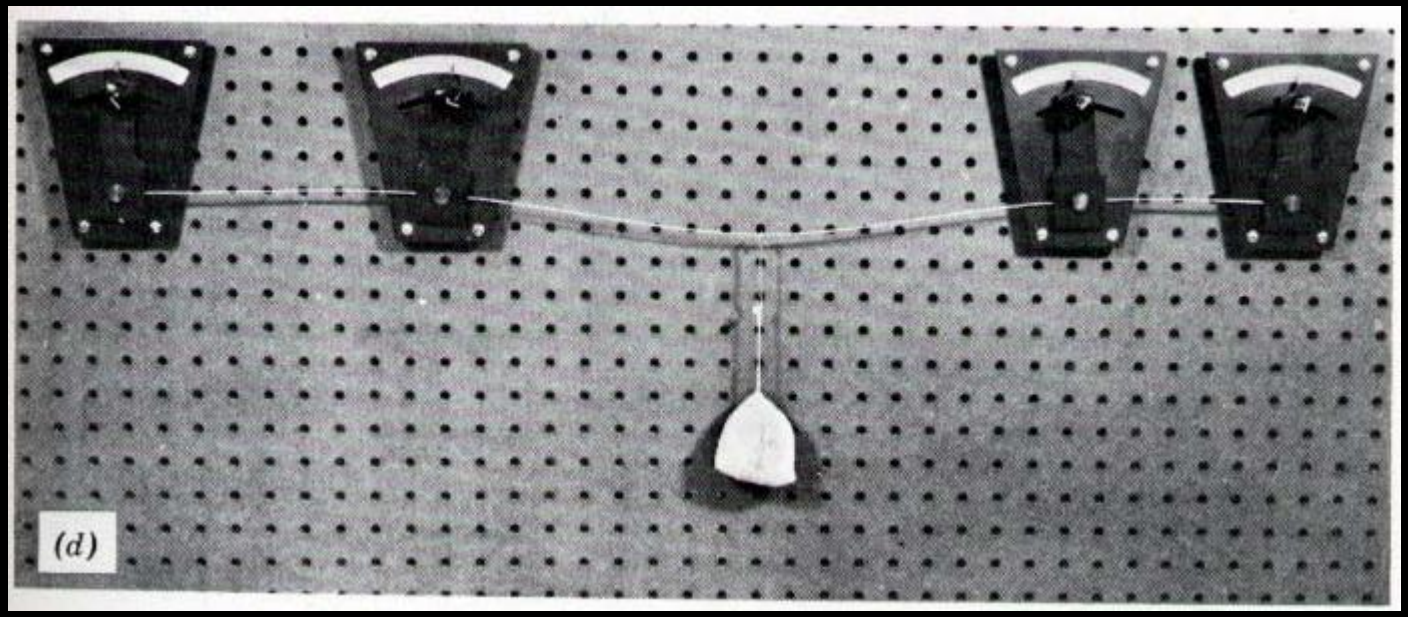
Moment Distribution Method (d)

- *release joint 3*



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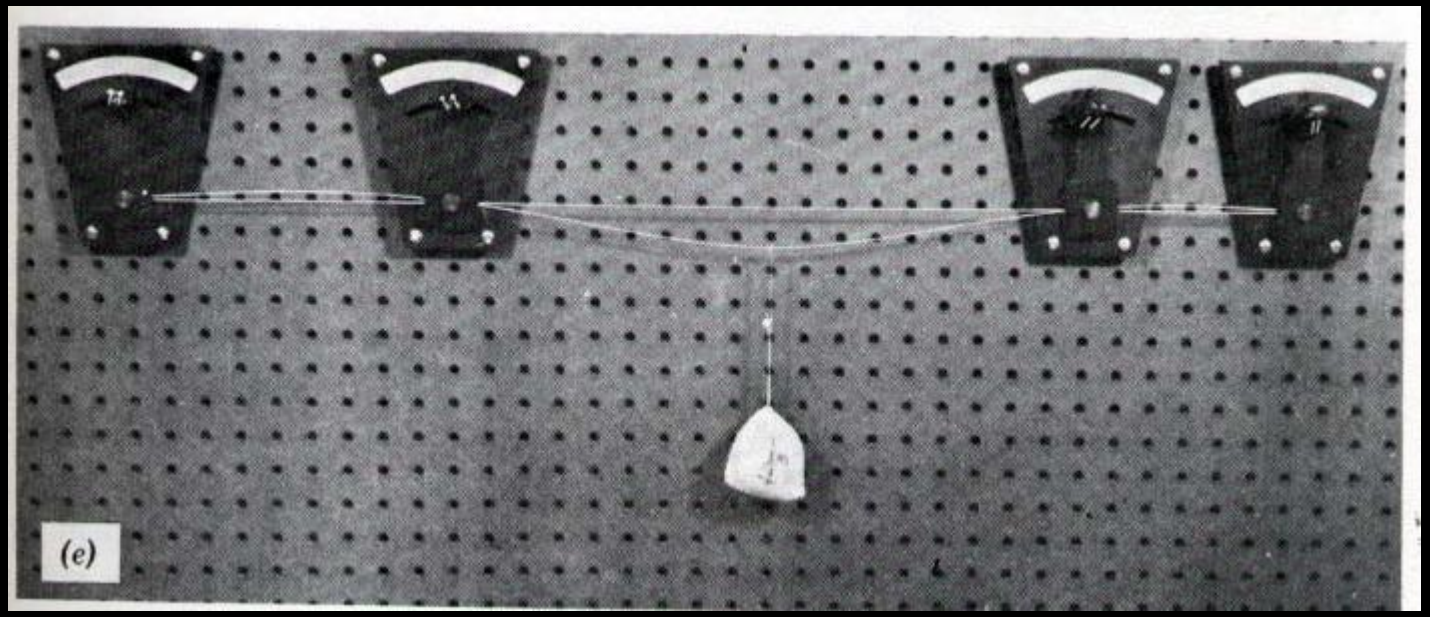
Moment Distribution Method (e)

- *exposure of final shape after cycles over initial shape*



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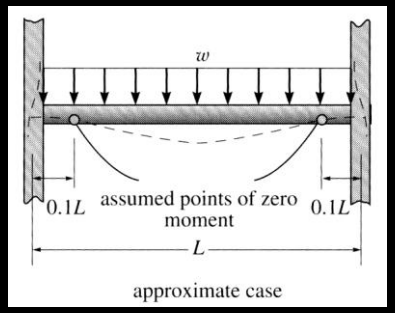
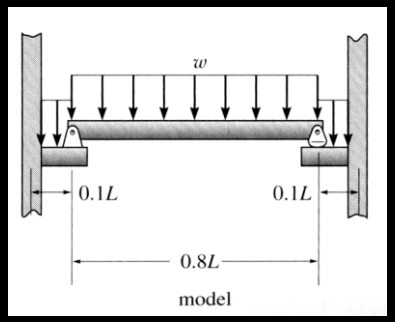
Analysis Methods

- *Approximate Methods*
  - *location of inflection points*
- *Force Method*
  - *forces are unknowns*
- *Displacement Method*
  - *displacements are unknowns*





Theorem of Three Moments

- *moments at three adjacent supports (2 spans)*
- *distributed load and same I:*

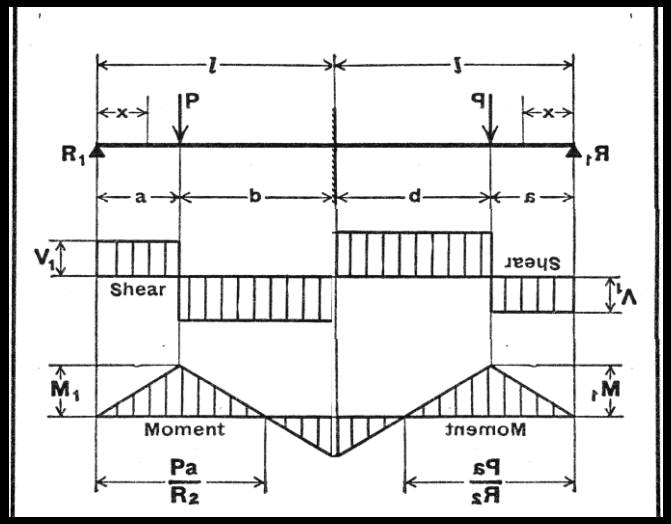
$$M_1 L_1 + 2M_2\left(L_1 + L_2\right) + M_3 L_2 = -\frac{w_1 L_1^3}{4} - \frac{w_2 L_2^3}{4}$$

- *concentrated loads and same I:*

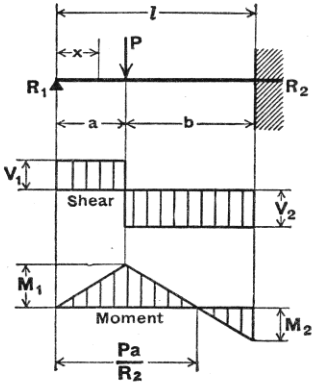
$$M_1 L_1 + 2M_2\left(L_1 + L_2\right) + M_3 L_2 = -\sum P_1 L_1^2\left(n_1 - n_1^3\right) - \sum P_2 L_2^2\left(n_2 - n_2^3\right)$$

Two Span Beams & Charts

- *equal spans & symmetrical loading*
- *middle support as flat slope*



14. BEAM FIXED AT ONE END, SUPPORTED AT OTHER— CONCENTRATED LOAD AT ANY POINT



$R_1 = V_1 \ldots = \frac{Pb^2}{2l^3}(a+2l)$

$R_2 = V_2 \ldots = \frac{Pa}{2l^3}(3l^2-a^2)$

M_1 (at point of load) $\ldots = R_1 a$

M_2 (at fixed end) $\ldots = \frac{Pab}{2l^2}(a+l)$

M_x (when $x < a$) $\ldots = R_1 x$

M_x (when $x > a$) $\ldots = R_1 x - P(x-a)$

Δmax. (when $a < .414l$ at $x = l\frac{l^2+a^2}{3l^2-a^2}$) $= \frac{Pa}{3EI}\frac{(l^2-a^2)^3}{(3l^2-a^2)^2}$

Δmax. (when $a > .414l$ at $x = l\sqrt{\frac{a}{2l+a}}$) $= \frac{Pab^2}{6EI}\sqrt{\frac{a}{2l+a}}$

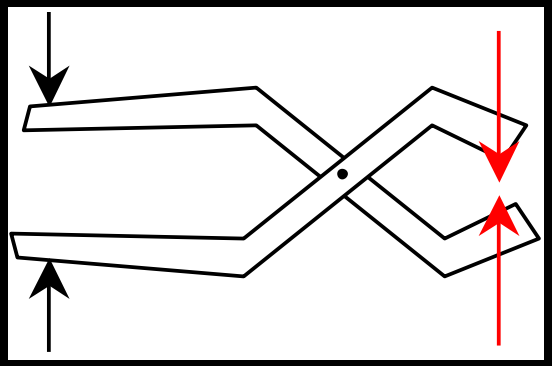
Δa (at point of load) $\ldots = \frac{Pa^2b^3}{12EIl^3}(3l+a)$

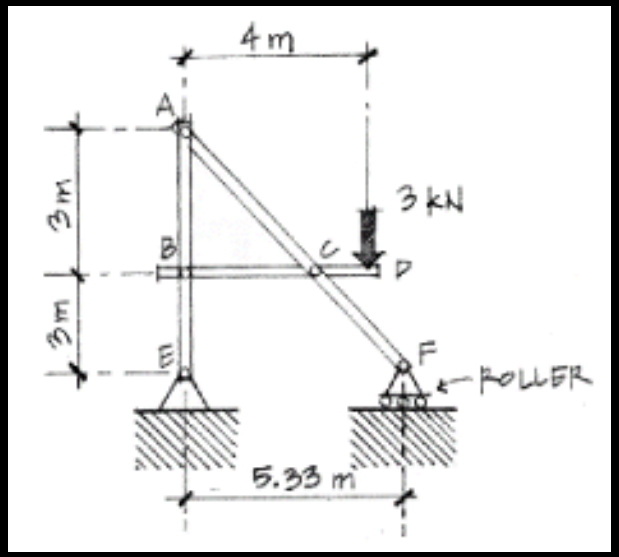
Δx (when $x < a$) $\ldots = \frac{Pb^2x}{12EIl^3}(3al^2-2lx^2-ax^2)$

Δx (when $x > a$) $\ldots = \frac{Pa}{12EIl^3}(l-x)^2(3l^2x-a^2x-2a^2l)$

Pinned Frames

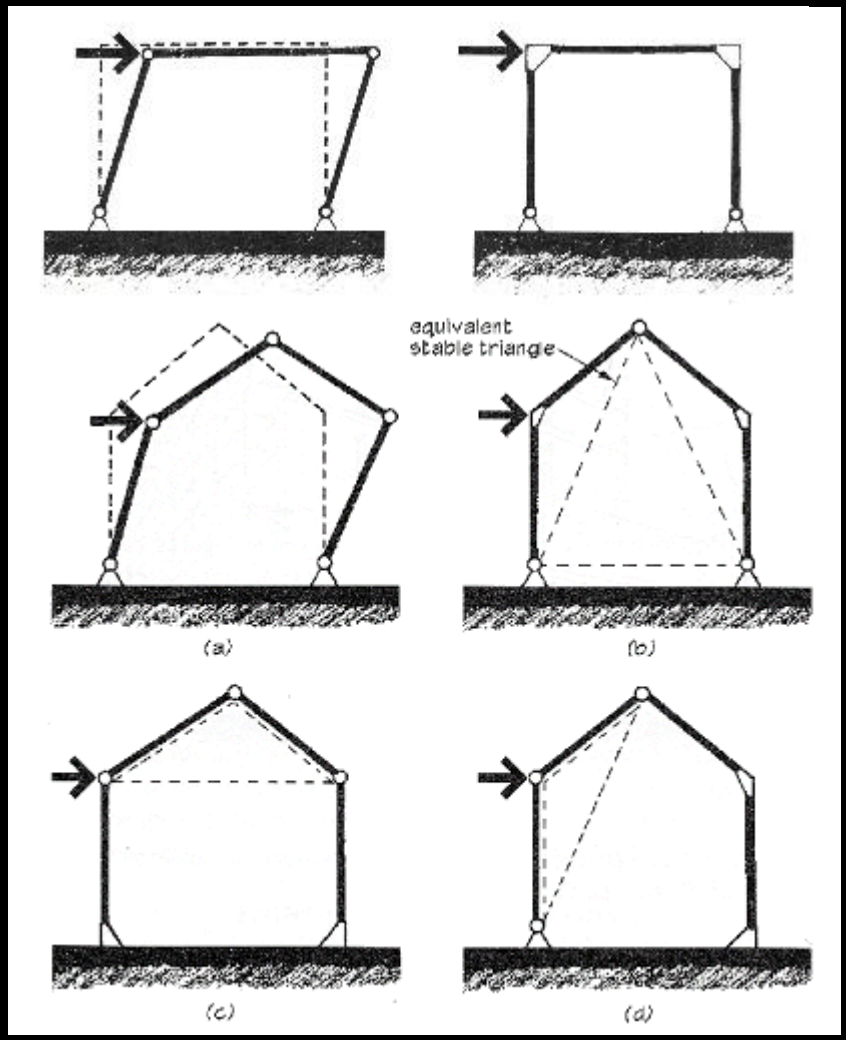
- *structures with at least one 3 force body*
- *connected with pins*
- *reactions are equal and opposite*
  - *non-rigid*
  - *rigid*





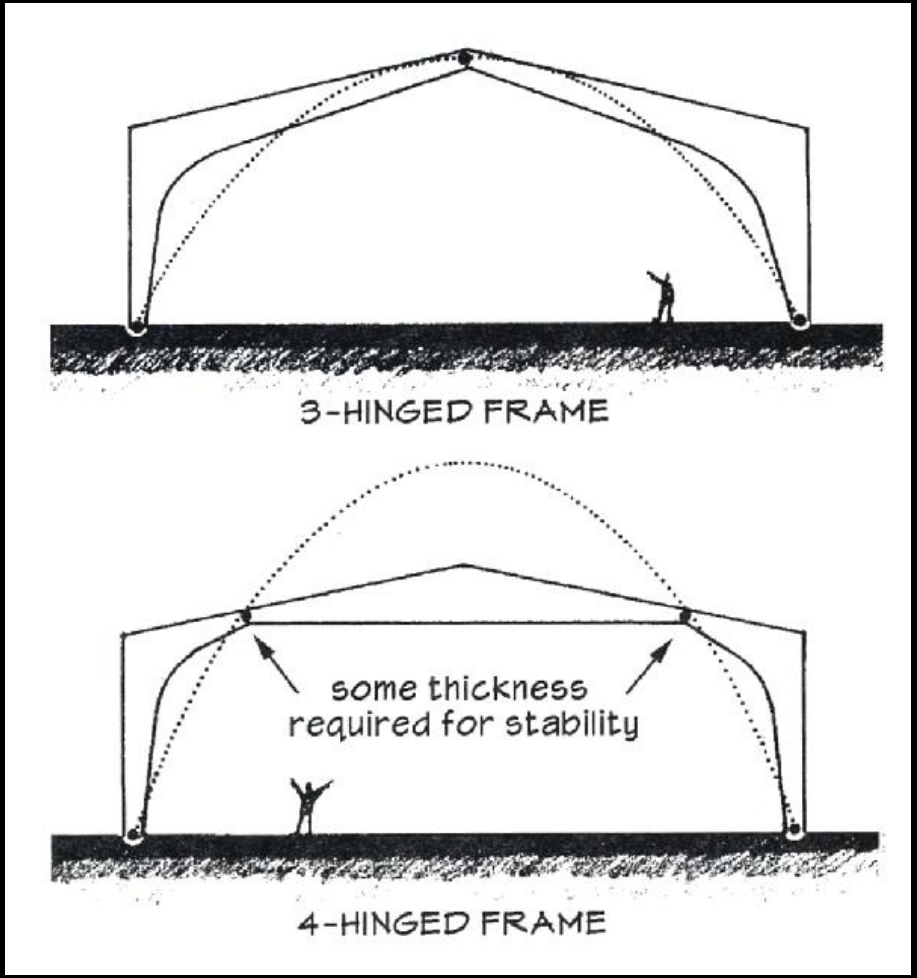
Rigid Frames

- *rigid frames have no pins*
- *frame is all one body*
- *typically statically indeterminate*
- *types*
  - *portal*
  - *gable*



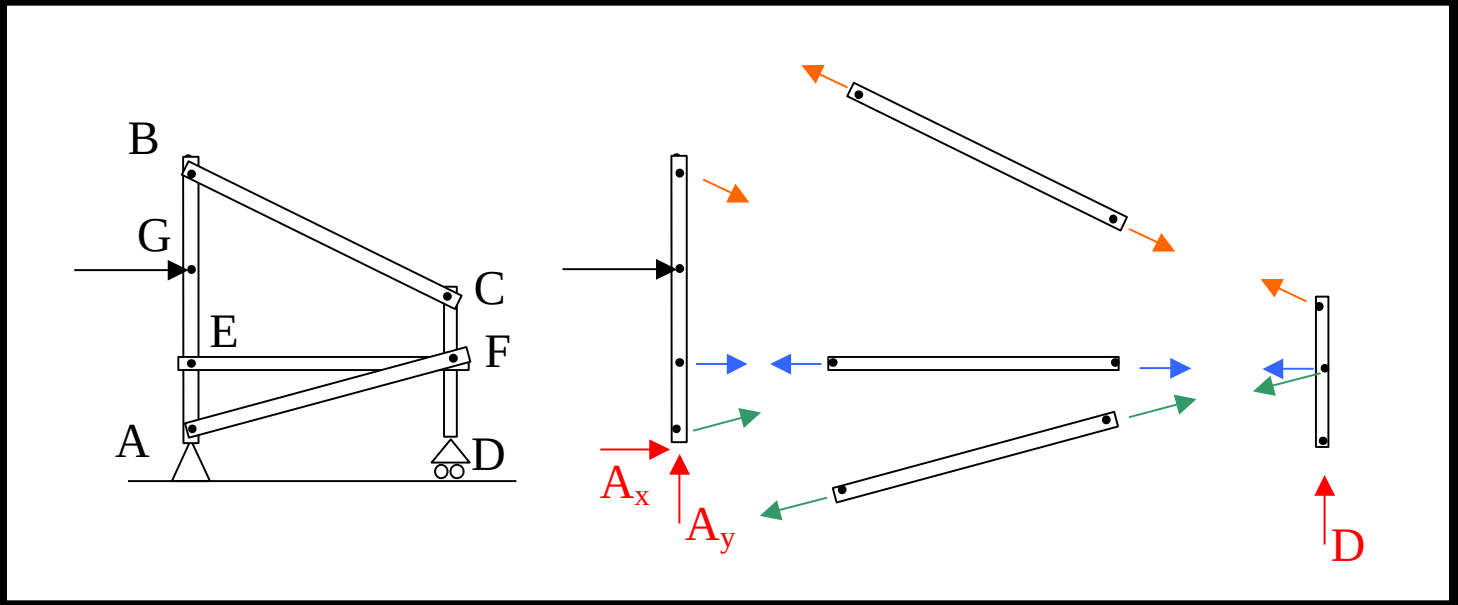
Rigid Frames with PINS

- *frame pieces with connecting pins*
- *not necessarily symmetrical*



Internal Pin Connections

- *statically determinant*
  - *3 equations per body*
  - *2 reactions per pin + support forces*

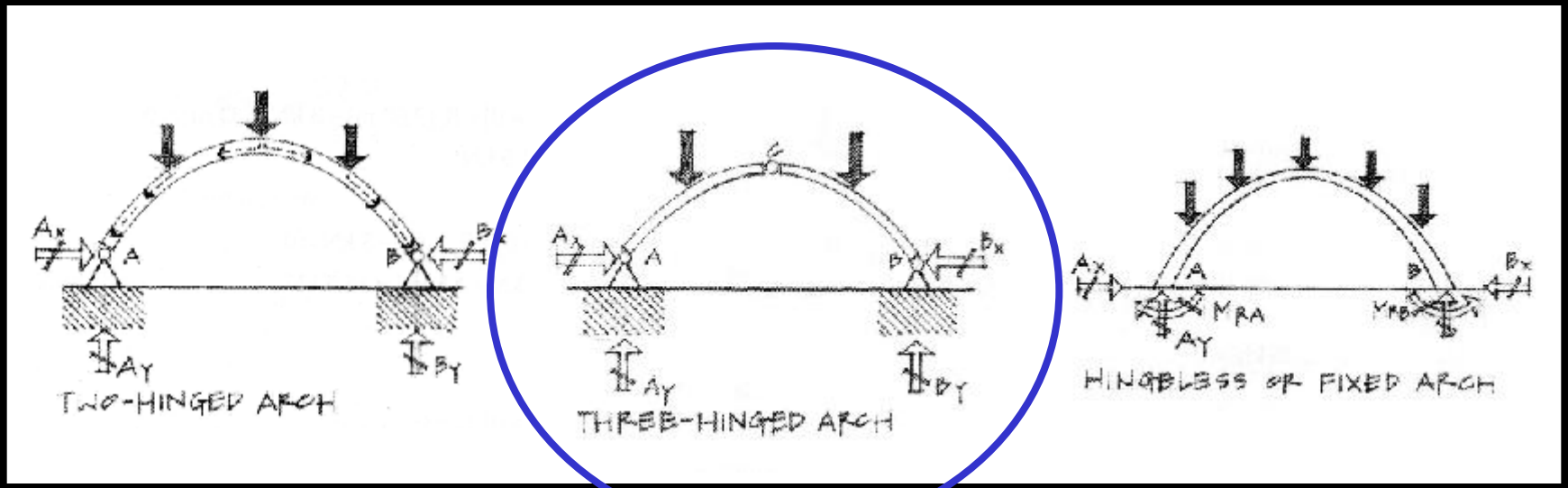


Arches

- *ancient*
- *traditional shape to span long distances*

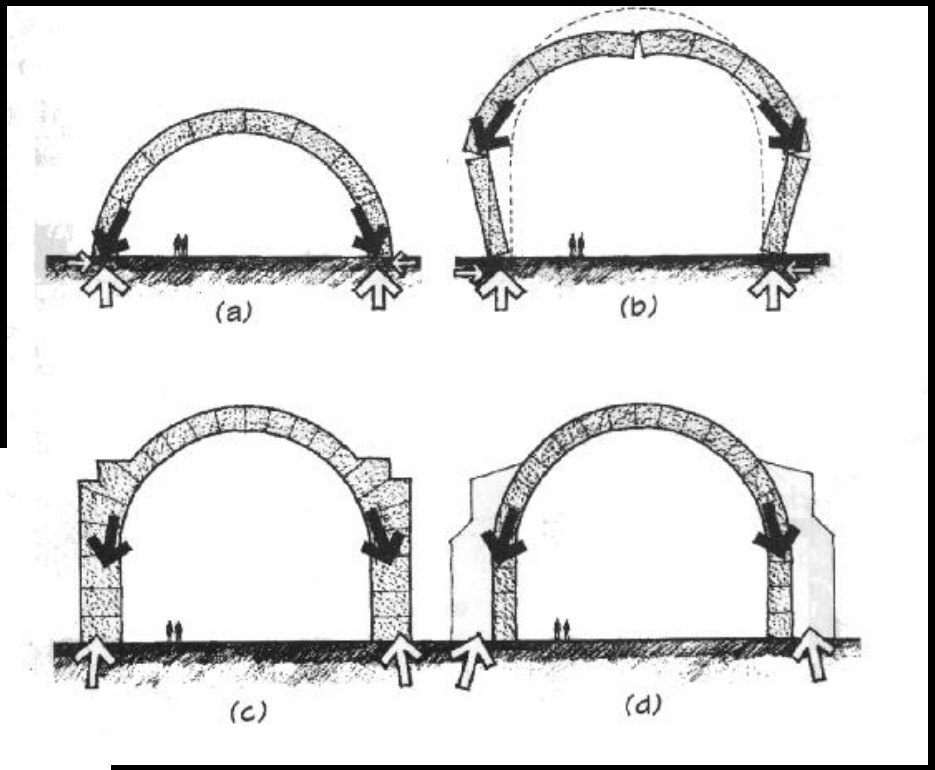
Arches

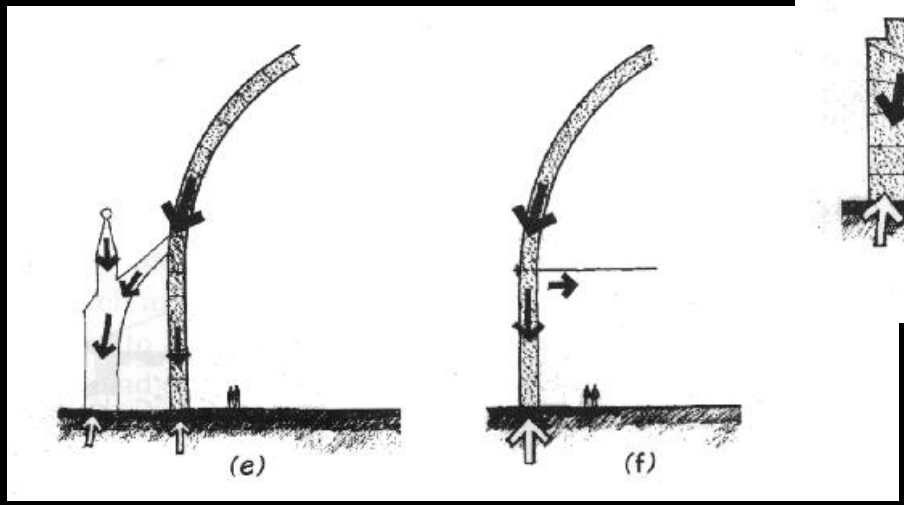
- *primarily sees compression*
- *a brick "likes an arch"*



Arches

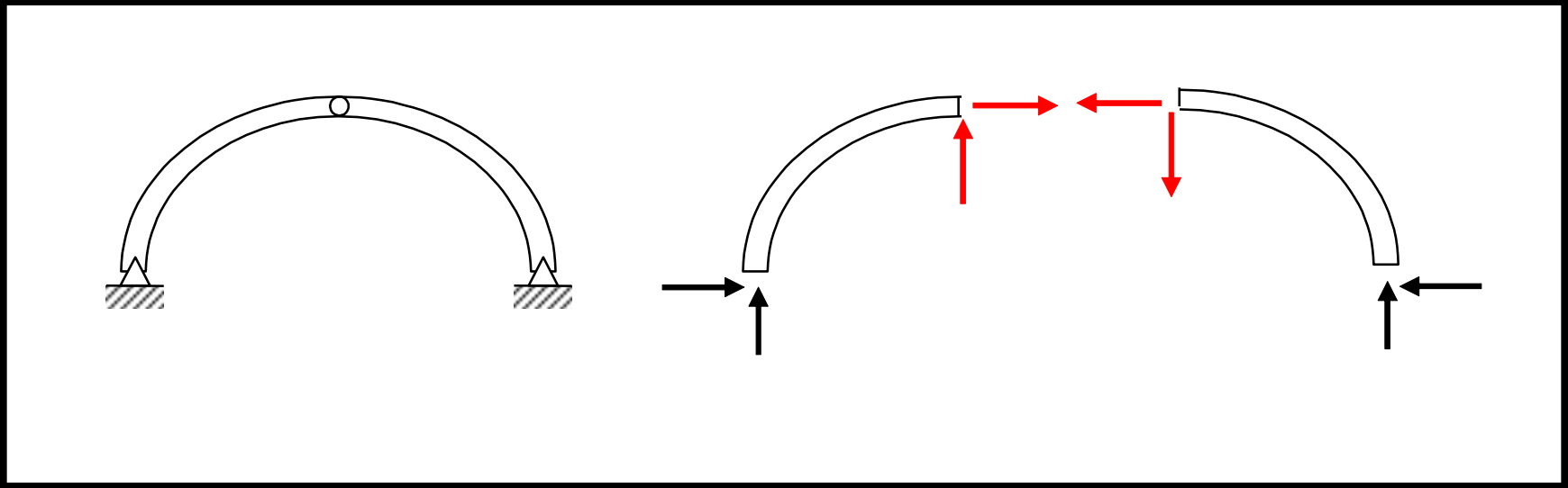
- *behavior*
  - *– thrust related to height to width*





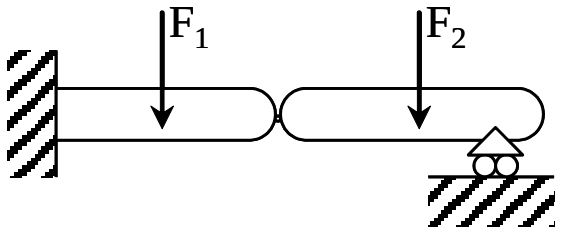
Three-Hinged Arch

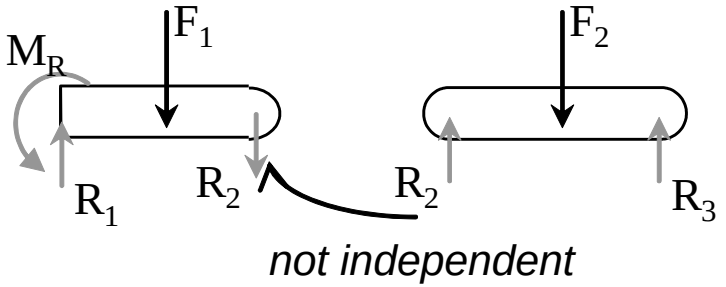
- *statically determinant*
  - *– 2 bodies, 6 equilibrium equations*
  - *– 4 support, 2 pin reactions (= 6)*



Beams with Internal Pins

- *statically determinant when*
  - *3 equilibrium equations per link =>*
  - *total of support & pin reactions (properly constrained)*
- *zero moment at pins*





Procedure

- *solve for all support forces you can*
- *draw a FBD of each member*
  - *pins are integral with member*
  - *pins with loads should belong to 3+ force bodies*
  - *pin forces are equal and opposite on connecting bodies*
  - *identify 2 force bodies vs. 3+ force bodies*
  - *use all equilibrium equations*